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Growth Performance of the African Catfish (*Clarias gariepinus*) Fry Raised in Plastic Vats with Duckweed (*Lemna minor)*

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ABSTRACT

The poor utilization and high cost of commercial fish feed is a major constraint in aquaculture. This study investigated the viability of using *Lemna minor* (duckweed) to improve the utilization of commercial fish feed in raising *Clarias gariepinus* fry. The 3 trial experiment had five treatments: T_0 (Control), fed commercial feed only; T_1, fed commercial feed with Duckweed; T_2, Duckweed only in the first three weeks before adding commercial diet; T_3, Duckweed in the culture medium for last three weeks only before adding commercial diet; and T_4, without commercial feed but Duckweed only for the culture period. The results showed that T_1 has significantly improved growth performance compared to the control (T_0) as evident in higher final body weight (28.01±3.26, 24.02±0.23), mean weight gain (25.80±3.24, 21.79±0.20), and specific growth rate (6.04±0.27, 5.70±0.05), respectively. Feed utilization parameters also favoured treatments with a combination of duckweed and commercial feed. Thus, duckweed can be a valuable complement to commercial feed, potentially reducing feed waste without compromising the growth and survival of *Clarias gariepinus.*

Keywords:

Clarias gariepinus, Lemna minor, Nutrient, performance

Introduction

Among the commonly farmed fish in Africa is the African catfish, *Clarias gariepinus*. However, catfish production is often hindered by several factors, including high feed cost and low-quality feed, which can limit fish growth and survival (Kosasih *et al.*, 2017). Catfish culture has overtime become the desire of most fish farmers due to its continuous increasing demand (Kumar *et al.*, 2020). It is often reared in ponds or concrete tanks. Plastic vats are becoming more popular owing to their advantage in portability, flexibility, easy cleaning, low maintenance, water quality control, disease prevention, cost-effective, and space efficiency. This informed the use of plastic vats in this study.

In a bid to cut down production cost, farmers sought to replace the expensive fish meal with alternative plant protein sources (Ayadi *et al.*, 2012). Some of these plants have shown high bioremediation potentials and possibly helping to promote feed utilization in fish culture. The utilization of aquatic weeds may be the great option to fix the existing problems associated with fish feeding in aquaculture. Aquatic macrophytes availability has constituted a nuisance (Aghoghovwia *et al.*, 2018) to the ecology of various water bodies due to high regenerative capacity within a short duration. Most of these macrophytes have been assessed for their nutritional content (Sonta *et al.*, 2019), anti-nutritional factors

(Xu *et al.*, 2021), and amino acid profile (Chakrabarti *et al.*, 2018) using different processing methods (Ifie *et al.*, 2021) to increase the compositional value (Irabor *et al.*, 2022) of the macrophytes.

Duckweeds belong to the family *Lemnaceae* which represent a small family of aquatic floating monocots plant consisting of 37 species in 5 genera. It has global distribution and inhabits small shallow bodies of water in tropical and boreal environments (Acosta *et al.*, 2021). In the angiosperm plants family, they are the fastest to grow (Sree *et al.*, 2015); and form a continuous layer of mats on or underneath the water surface (Sonta *et al*., 2019). Duckweed can contain 28%-43% crude protein, 5% fiber (dry weight), and high concentrations of minerals, such as phosphorus and potassium, as well as xanthophylls and carotenes (del-Carmen-Flores-Miranda *et al.*, 2015). Eyiwunmi *et al.*, (2022) investigated the effects of treated duckweed meal (DWM) as soybean substitute, and reported that the value of alkaloid (%) was significantly ($p<0.05$) increased from 4.10±0.58 (raw sample) to 4.70±0.01 (treated sample). They reported that the raw duckweed (*Lemna minor*) has the composition shown in Table 1;

Table 1: Proximate composition of raw duckweed meal

Parameters	%
Dry Matter	92.02
Moisture content	7.98
Crude Protein (CP)	22.70
Ash	19.80
Ether Extract	3.30
Crude Fibre (CF)	7.70
NFE	38.52

Islam *et al*. (2014), worked on dietary inclusion of duckweed (*Lemna minor*) showing positive effects on growth, whole body composition, and haematological and immunological parameters in rainbow trout, *Oncorhynchus mykiss.* Findings have proved that aquatic plants especially duckweed is a potential in feed formulation for other fish (Baek *et al*., 2021), which is considered as a blessing for the fishery industry, against the previous school of thought that sees them as impediment. This is particularly become necessary if aquaculture must meet the world's population demands for food fish to augment the shortfall from capture fisheries (Fakunle *et al.*, 2009). There exist paucity of knowledge on the influence of live Duckweed on the growth performance of *Clarias gariepinus* fed commercial fish feed, even though it has proven to be a good additive to feed as an ingredient (Kio and Ola – Adams, 1987), for improving fish feed at reduced cost. This study aims to assess the growth performance of *Clarias gariepinus* fry raised in plastic vats with *Lemna minor*. The impact of different levels of duckweed on the growth rate, survival and performance index of the African catfish fry was evaluated.

Materials and Methods

This experiment was carried out over a period of 6 weeks at the Department of Aquaculture and Fisheries Management fish farm, Faculty of Agriculture, University of Benin, Benin City Edo State. The experiment was laid out in a Completely Randomized Design (CRD). Fifteen rectangular plastic vats with a dimension of (0.50 x 0.38 x 0.3 m^3) were used. 25 *Clarias gariepinus* fry were allotted into

each of the fifteen bowls and fed for a period of six weeks. Each of the five treatments had three replicates.

a. **T_0** (Control)**:** fed commercial feed only without duckweed all through.

b. **T_1:** Duckweed and Commercial diet throughout the 6 weeks.

c. **T_2:** Duckweed without commercial feed in the first 3 weeks and commercial diet added in the last 3 weeks.

d. **T_3:** Duckweed added in the last three weeks and commercial diet only, used in the first three weeks.

e. **T_4:** Duckweed only for the six weeks

Experimental procedure

The plastic bowls were properly washed and rinsed with clean water. Places where all vats had equal access to illumination. They were filled in equal volumes with good quality water and the water in rearing vats was changed by siphoning twice per week. Mortalities were checked and recorded every time before feeding. Fresh duckweed (*Lemna minor*) was collected from the water surface using a large plastic sieve, drained, packed in draining sacks, and transported to the Department of Aquaculture and Fisheries Management fish farm, Faculty of Agriculture. The weed was identified using appropriate aquatic flora systematic key. Duckweeds of an average weight of 5g (mean wet weight) were assigned to triplicate group of plastic vat containing the water such that the entire surface of the water was covered by a single layer of fronds in the treatment with the weed added.

Selection of experimental fish

300 hundred *C. gariepinus* healthy fry all with the same genetic background and nutritional history were obtained from a commercial fish hatchery in Benin City. They were transported to the Department of Aquaculture and Fisheries Management fish farm in plastic containers and were allowed to acclimatize for 3 days while they were fed 0.6mm floating pelleted commercial feed before the commencement of the experiment.

Feeding of experimental fish

20 fry were stocked in the 18l volume of water in each vat. The experimental fry in the different rearing facility were fed to satiation thrice daily; 8 am, 1 pm and 6 pm. The feeding was done manually to avoid pollution of culture water.

Data Collection

Weighing of experimental fish

Weighing of fish was done using an electrical weighing balance (model: 3002N, No.110628014, made in Shangai, China by Wart Instrument Co. Ltd) before the experiment commenced as well as once in two weeks during the period of the experiment. Fry were randomly selected from all the replicates in each group and weighed. At the end of the experiment, the individual weights of all the surviving fingerlings from all the groups were measured to obtain their final mean weight.

Growth parameters

Growth parameters were obtained following the recommendations of Adewolu and Adamson (2011).

(a) Mean Weight Gain (MWTG)

$$MWTG = Final\,Body\ weight - Mean\ Initial\ Body\ Weight$$

(b) Percentage Weight Gain (PWG)

$$PWG = \frac{Mean\ Weigt\ Gain\ Mean}{Initial\ Weight} \times 100$$

(c) Specific Growth Rate (SGR)

$$SGR = \frac{ln\ FBW - ln\ IBW}{D} \times 100$$

Where:

ln = Natural logarithm

D = Number of days between weighing

FBW = Final body weight

IBW= Initial body weight

Determination of Feed Utilization

The feed conversion ratio (FCR) was calculated for each by first measuring the total amount of feed consumed by each treatment using the digital scale. Then the calculated total body weight gained by the fry in each facility was arrived at by subtracting the initial weight from the final weight

This is calculated as:

$$\text{Food Conversion Ratio} = \frac{\text{Total Feed consumed [g]}}{\text{Total Body weight gained [g]}}$$

Feeding Efficiency was calculated as the invers of FCR. The feed intake (FI) was obtained by adding weekly mean feed intake (MFI) of fish under each treatment for the experimental period.

Determination of survival rate

This was determined as follows:

$$\text{Survival Rate (SR\%)} = \frac{\text{Number of live fingerlings at sampling time } t}{\text{Number of fish initially stocked}} \times 100$$

Obtained data were subjected to Analyses of Variance, ANOVA, and differences between means were separated using Duncan Multiple Range Test at 5% probability using Genstat v21Statistical package.

Results

The results of the growth performance, survival rate and performance index of *C. gariepinus* cultured in plastic bowls containing duckweed is presented below.

General growth parameters

The results of the growth parameters are shown in Table 2,

Table 2; Growth performance parameters of *Clarias gariepinus* cultured in plastic vats

Growth parameters	T_0	T_1	T_2	T_3	T_4
Mean Initial Body Weight (MIBW)(g)	2.22±0.03^{a}	2.20±0.03^{a}	2.28±0.11^{a}	2.29±0.05^{a}	2.20±0.02^{a}
Mean Final Body weight (MFBW)(g)	24.02±0.23^{ab}	28.01±3.26^{a}	18.03±4.03^{c}	22.77±0.15^{b}	6.90±0.78^{d}
Mean Body Weight Gain(MBWG) (g)	21.79±0.20^{ab}	25.80±3.24^{a}	16.05±3.92^{c}	20.48±0.20^{b}	4.70±0.77^{d}
Percentage weight Gain (PWG)(%)	980.23±3.06^{a}	1170.55±138.95^{b}	804.93±155.71^{a}	897.28±26.05^{a}	213.53±33.88^{c}
Specific Growth Rate (SGR)(%)	5.70±0.05^{ab}	6.04±0.27^{b}	5.22±0.42^{a}	5.31±0.17^{a}	2.71±0.26^{c}
Survival Rate (SR) (%)	97.00±0.00^{a}	93.00±0.00^{a}	97.00±0.00^{a}	100.00±0.00^{a}	89.00±0.00^{a}
Performance index (%)	50.33±0.46^{a}	57.13±7.18^{a}	37.06±9.06^{b}	48.76±0.46^{a}	9.96±1.63^{c}

Mean Initial Body Weight (MIBW)

There was no significant difference (P>0.05) in the initial weight of fish in all the treatments. This was intended to avoid bias in the experiment.

Mean Final Body Weight (MFBW), Mean Weight Gain (MWG), Specific Growth Rate (SGR)

The Final weight of fish was highest in T_1 (28.04g), which was significantly different (p>.0.05) from final weight of fish in T_2 (18.03g), T_3 (22.77g) and T_4 (6.90g), with T_4 being the lowest. The highest mean weight gain was recorded in T_1 with a value of (25.80g) and the lowest value (4.70g) in T_4. Among all the treatments, T_1 (6.04g) produced the best mean Specific Growth Rate in the *Clarias*. This was significantly higher than those of other treatments. This performance was closely followed by that obtained from fish in T_0 (5.70g). T_2 (5.22g) and T_3 (5.31g) were not significantly different (P>0.05) but gave better performance in *Clarias* than T_4 (2.71g).

There was a significant difference in the growth performance of the fish, with T_1 showing the highest mean final body weight and mean weight gain. This may be due to the additional nutrients supplied by the duckweed providing supplementary food source for the catfish alongside their commercial feed (El-Sayed, 2009). Previous studies have shown that a combination of commercial feed and alternative feed sources, such as duckweed, can improve growth performance in fish (Hossain *et al.,* 2015). In terms of specific growth rate, T_1 also outperformed the other treatments, again highlighting the benefits of a combined diet of commercial feed and duckweed. The specific growth rate is an important indicator of the growth potential of fish, and the results in this study suggest that a combination of different feed sources can enhance growth performance. On the other hand, T_4, which had only duckweed for the entire duration of the experiment, showed the lowest growth performance. This suggests that a diet solely consisting of duckweed may not provide sufficient nutrients for optimal growth in *C. gariepinus.* Studies have also shown that an exclusive diet of duckweed may not meet the nutritional requirements of fish, leading to suboptimal growth performance (Islam *et al.,* 2014).

T_2 and T_3 displayed intermediate growth performance. The initial feeding regime might have impacted the fish's ability to utilize nutrients effectively when switched to a different diet later. A potential explanation could be a disruption in gut micro biota, which takes time to adapt to varying food sources similar to the findings of Nayak and Fernandes (2015), while working with *Pangasius hypophthalmus*.

Survival Rate (SR)

The highest level of mortality was recorded in T_4 with 89% survival rate while other treatments showed 90% and above. The survival rates did not differ ($P>0.05$) among the four treatments. This can be attributed to the good water quality maintained throughout the culture period ie good water quality parameters that were within the recommended range for fish culture (Ngugi *et al.,* 2007) may have contributed to the high survival rate in all treatments.

Performance index

Overall the fish in T_1 had the best performance index. The performance index reflects the overall growth and survivability of the fish. The highest performance index in T_1, followed closely by T_2, may be attributed to the higher increase in growth combined with lower mortality recorded in these treatments. T_4 had the lowest performance index, aligning with the lower growth performance observed in terms of final body weight, specific growth rate and survival rate.

Feed utilization

Table 3: Feed Utilization of *Clarias gariepinus*

	T_0	**T_1**	**T_2**	**T_3**
Mean Feed Intake (MFI) (g)	26.61 ± 0.31^a	25.33 ± 0.08^b	20.14 ± 0.16^c	4.83 ± 0.05^d
Feed Conversion Ratio (FCR)	1.22 ± 0.03^a	0.99 ± 0.13^a	1.31 ± 0.32^a	0.24 ± 0.00^b
Feed Efficiency (FC)	0.83 ± 0.01^a	1.02 ± 0.13^a	0.80 ± 0.19^a	4.23 ± 0.02^b

Feed Intake (FI)

The feed (commercial feed) intake (FI) of *C. gariepinus* fry was highly significantly different ($p \leq 0.05$) with the highest value of 26.61g recorded in fish in T_0 (control) while the lowest was 4.83g in T_3 (Table 3). This could be due to the limited feeding ability of the fry within the first three weeks and the poor acceptability of the feed type available during the last three weeks i.e. duckweed only. This disrupted the increased ability to feed on the commercial feed as the fish increases in age. Previous studies have highlighted the influence of diet availability composition on feed intake in fish. For example, studies by Hossain *et al.* (2015) and Islam *et al.* (2014) have shown that the attractiveness and nutritional value of feed can impact feed intake. T_1 also had a higher feed intake than other treatment but not as high as T_0, however the growth performance was higher compared to T_0 which indicated that the duckweed was consumed alongside their commercial feed.

Feed Conversion Ratio (FCR) and Feed Efficiency (FE)

From Table 3, T_3 seemingly had the best food conversion ability with a lowest value of 0.24g. However there was no significant ($p<0.05$) difference between the food conversion ratio of T_0, T_1 and T_2. The FCR value for T_3 can be attributed to the fact that the fry were fed with the commercial feed for the first three weeks, when growth is most rapid, only. Age of the fish and the small amount feed taken by the fry at this stage all influence the figures. Similarly, T_3 had the highest feed efficiency and was significantly different at $p<0.05$ from the other treatments. T_1 had better feed conversion ratio and feed efficiency compared to the rest treatments in all the trials. This suggests that the growth of the duckweed in the culture water throughout the culture period helped in the feed utilization.

Conclusion

The treatments had significant effect on the growth and feed utilization ($p \leq 0.05$) of *Clarias gariepinus*. Mean final body weight, mean percentage weight gain, specific growth rate were highest in fish fed commercial diet and duckweed in 6 weeks (T_1). The survival rate was also high (93%). Fish raised only on duckweed recorded the lowest growth parameters and survival rate. This study has demonstrated that duckweed has the potential to partly complement commercial diet, thus capable of reducing cost of feeding this species. This would considerably improve fish feed utilization without compromising survival rate and growth performance of the African catfish.

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